WATER REUSE AND ENVIRONMENTAL CONSERVATION PROJECT

CONTRACT NO. EDH–I–00–08–00024–00 ORDER NO. 03

AL-EKEDER DISPOSAL FACILITY MASTER PLAN

December 2014

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December 2014

Submitted to:
USAID Jordan

Prepared by:
AECOM

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LIST OF APPENDICES

LIST OF ACRONYMS

ASL	Above Sea Level
ASTM	American Society for Testing and Materials
CQA	Construction Quality Assurance
ET	Evapotranspiration
HDPE	High Density Polyethylene
JSC	Joint Services Council
MRF	Materials Recovery Facility
MSW	Municipal Solid Waste
QA	Quality Assurance
RDF	Refuse Derived Fuel
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Department
WAJ	Water Authority Jordan

1.0 INTRODUCTION

The USAID Water Reuse and Environmental Conservation Project works throughout Jordan in institutional capacity building, pollution prevention for industries, solid waste and wastewater management, and water reuse. The project is implemented by AECOM and a team of international and Jordanian partner firms. Work on the project is authorized under Order Number 3 in accordance with USAID Contract Number EDH-I-00-08-00024-00 for Global Architect-Engineering Infrastructure Services, as issued to AECOM Technology Corporation (AECOM).

This five-year project has four primary tasks:

- Task 1 – Institutional and Regulatory Strengthening
- Task 2 – Pollution Prevention and Industrial Water Management
- Task 3 – Disposal Sites Rehabilitation and Feasibility Studies
- Task 4 – Water Reuse for Community Livelihood Enhancement, including Biosolids

As part of Task 3, the project team is to prepare a holistic and integrated master plan for the Ekeder Disposal Facility operations, site management, land-use, and its expansion.

This document presents background information about the Ekeder Disposal Facility; its operations; current challenges (including waste intake rates); design and planning narratives, and recommendations for sustained operations and environmental conservation. The appendices contain supportive information and data, i.e. site photos (Appendix A), an updated waste characterization study (Appendix B), rendered diagrams depicting the sequencing of major work activities (Appendix C), and conceptual engineering design drawings of existing conditions and the engineered components of the proposed operating strategy (Appendix D). This report is based on previous project studies and assessments pertaining to the Site; updated topographic survey; field visits and consultations with relevant figures.

2.0 EKEDER DISPOSAL FACILITY

The Ekeder Disposal Facility is the second largest disposal site in Jordan, serving about 100 towns and villages in the northern region of the country. Several parties are involved in governing the Ekeder disposal site (the Greater Irbid Municipality, Ramtha Municipality, Yarmouk University, the Water Authority of Jordan (WAJ), and the Joint Service Council (JSC) for the North); the latter of which is currently responsible for the operation of the facility. The site has additional importance because it is located approximately 1 km south of Jordan's international border with Syria.

The Ekeder Disposal Facility commenced operation in 1980. Liquid waste (initially restricted to municipal sludge) disposal capacity was initially controlled by four lagoons. By 1998 the number of lagoons was increased to seven, in order to receive liquid waste from olive oil production mills (locally known as Zibar) in dedicated lagoons. Dramatic increases in mixed liquid waste generation and disposal at Ekeder eventually caused one of the dikes separating the lagoons to fail. This situation developed into a much larger environmental problem by 1999, when the retaining dikes of several adjacent lagoons breached allowing wastewater to exit the site. To preclude this from occurring again, ten additional lagoons were installed by 2006 to provide additional storage and overflow capacity. However, new challenges to the facility arose in 2011 following the massive influx of Syrian refugees into host communities in the Northern region and the Za'atari refugee camp. This dramatically increased waste generation rates and further stressed the limited airspace and operational capacity of the facility, ultimately leading to the site's designation as an environmental 'hotspot' in Jordan.

To date, the Ekeder Disposal Facility consists of 15 liquid industrial wastewater disposal lagoons in addition to a municipal solid waste landfill. Municipal wastewater liquid sludge, olive oil mill wastewater (Zibar) and industrial wastewater are discharged into earthen lagoons at the site, allowing the aqueous fraction to evaporate. Only one of the 15 wastewater lagoons is lined. Almost all liquid wastes are discharged together in the earthen lagoons throughout the site. Only Zibar is disposed of separately.

The objective of this subtask is to prepare a comprehensive Master Plan for the Ekeder Disposal Facility in order to allow for safe utilization of the disposal site and to mitigate, if not eliminate, future environmental and safety issues.

2.1 Site Location

As shown in Figure 2.1, the Ekeder disposal site is located in the Mafraq Governorate in Northern Jordan. The facility lies approximately 27 km east of the City of Irbid and 1 km south of the Syrian border. The nearest village, also called Ekeder, is situated about 2 km to the southwest of the site boundaries.

The site covers 806,000 square meters. The topography of the landfill is characterized as hilly to semi-flat with a gradient of approximately 2% from East to West, with an elevation of about 650 m above sea level (ASL).

Figure 2.1*:* General Location of the Ekeder Disposal Facility

The climate of the site is best characterized by records from the Ramtha Meteorological Station – the closest weather station to the Ekeder Disposal Facility. Available climate measurements taken between 2003 and 2013 have been averaged out and presented in Table 2.1.

Table 2.1.
Averaged data from Ramtha Meteorological Station, E 32 30', N 35 59', Elevation = 590 m

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Mean Air Temp (ºC)	9.2	10.0	13.0	16.8	21.1	24.0	26.0	26.3	24.2	21.0	15.2	10.5	**18.1**
Mean Max. Air Temp (ºC)	14.1	15.0	19.3	24.1	28.9	31.9	33.5	33.7	31.4	27.8	21.4	16.0	**24.8**
Mean Min. Air Temp (ºC)	4.2	4.9	6.7	9.6	13.2	16.0	18.5	18.8	17.0	14.0	9.0	5.0	**11.4**
Total Rainfall (mm)	54.2	63.8	26.5	12.1	2.1	0.3	0.0	0.0	0.2	9.1	20.8	37.3	**226.5**
Mean Relative Humidity (%)	73.3	73.1	64.1	58.9	51.7	52.3	56.7	60.2	59.6	56.5	62.1	66.1	**61.2**
Mean Wind Speed (Knot)	5.5	6.2	6.1	5.8	5.9	6.7	7.4	6.8	5.6	4.1	4.1	4.5	**5.7**
Total Evaporation, Class 'A' Pan (mm)	62.3	67.1	118.7	167.3	263.6	309.8	334.4	305.4	243.2	179.5	97.0	68.8	**186.8**

Data Source: Jordan Annual Climate Bulletin, Jordan Meteorological Department (2003-2013)

2.1.1 Site Geology

A geotechnical investigation of the Ekeder Disposal Facility was prepared in January 2012 and contains information relevant to the landfill (Triple Corporation Consultants and Engineers 2012). The following layered subsurface materials (starting from the top surface) were encountered during the geotechnical investigation:

1. **Fill materials** composed of very weak marl with gravel, cobbles and boulders of chert and chalky marly limestone

2. Brown, moist, stiff to very stiff **silty clay** with some gravel and cobbles of chert

3. Pale yellow, moist very weak **marl** with fragments of chalky marly limestone

4. Creamy, very weak **chalky marl** with fragments of chalky marly limestone

5. Creamy, to light rosy, highly fractured, highly weathered, weak to moderately weak **chalky marly limestone** with marl filling the fractures and intercalated with thin layers of dark brown chert.

6. Creamy, fractured, weathered, moderately strong **silicified limestone**

7. Dark brown, highly fractured strong **chert**

No free or confined groundwater was encountered in any of the boreholes and excavated test pits drilled at the site (to depths 20-28 m). Generally, the site area is mostly stable, and no caves, cavities, faults or other geological features were observed. A more comprehensive assessment of geological conditions relevant to the new solid waste area will be carried out during the detailed design phase of new cells.

2.2 Existing Operations

Currently, all wastes arrive at the disposal facility through the main entrance to the west, where trucks are weighed in at the scale facility and then directed to the applicable disposal area. The Ekeder disposal site is divided into two parts: the northern part is used for the landfilling of solid wastes, while the southern part is composed of 15 lagoons dedicated to the disposal of liquid wastes and a storage area for Kamkha (waste water from stone and marble cutting).

A summary of existing physical infrastructure and facilities is presented in Table 2.2. A collection of site photographs is presented in Appendix A.

Table 2.2: Summary of Physical Infrastructure and Existing Facilities at the Ekeder Disposal Facility

Component	Description
Scale house	• A single fixed truck scale is used for both liquid and solid wastes arriving at the facility • Source and quantities are recorded • Waste quantities are measured by weight
Power Supply	• Pole-mounted power transformer 33/0.4 kV provided by the Electrical Company (IDECO) near existing administrative offices
Storm Water Drainage	• No engineered storm water drainage system • Reported incidents of high volumes of rainfall surpassing lagoon storage capacity and flooding parts of the site and potentially permeating Syrian territory
Solid Waste Disposal (See Section 2.2.1, Solid Waste)	• Solid wastes are landfilled in the northern portion of the site • Solid waste disposal practices are non-compliant with environmental best practices • No liner or leachate collection system • Ineffective compaction and cover
Materials Recovery	• Contracted scavengers pay an annual fee for the right to manually extract salvageable materials from dumped waste.
Leachate Management	• Some leachate seeps through the sides of the active landfill onto the side of the road without control
Landfill Gas Collection	• No landfill gas collection or flaring • Numerous incidences of landfill fires
Liquid Waste Disposal (See Section 2.2.2, Liquid Waste Lagoons)	• Liquid industrial wastewater is disposed of in a series of 15 lagoons connected by channels or inlet pipes • Liquid waste is discharged into the lagoons from one of three receiving stations • Only one of the constructed lagoons (lagoon 8) is lined • Some lagoons are used specifically for Zibar
Access (See Section 2.2.3, Site Access)	• Accessible by road through a connection with the Jabber Roadway, leading to the Jabber border crossing with Syria • Site contains five major access roads

2.2.1 Solid Waste

The solid waste landfill facility receives solid waste generated in northern Jordan, which comprises roughly 100 towns and villages in addition to major urban centers. According to the landfill operator, the Ekeder disposal facility receives roughly 1300 metric tonnes of solid waste per day (2014 estimate).

Solid wastes arrive at the facility by means of individual trucks, which are weighed and source-identified at the scale house located at the main entrance in the western part of the site. After the weigh-in, solid waste transport trucks are directed towards the working face of the landfill in the northern part of the site. The solid waste is then dumped at the working face, where contracted scavengers (some of whom live near the disposal site) rummage through the waste to extract recyclable materials. The licensing to scavenge at the Ekeder Disposal Facility is subject to an annual tender process. The successful bidder pays the facility an annual fee for the authorization to remove recyclables from the waste at the landfill face prior to compaction, which is an inefficient process that poses potential safety and health concerns for the scavengers.

The remaining waste is then compacted. It is worth noting, however, that the effectiveness of compaction is restricted by the unavailability of specialized compaction equipment. Subsequently, the available landfill airspace at the site is being consumed very rapidly due to the low compaction of the waste and high waste intake. After compaction, the waste is then sometimes covered with excavated materials from a designated on-site borrow area or with residue from evaporated liquid wastes.

2.2.2 Liquid Waste Lagoons

According to recent records presented in the Ekeder development committee meetings by site operators, roughly 1,200 cubic meters of mixed liquid waste are disposed of at the facility on a daily basis in addition to approximately 130,000 m^3 of Zibar per season. As with solid wastes, tankers are weighed in and source-identified at the scale house before being directed to one of the three liquid waste receiving stations around the site for off-loading to lagoons. The first receiving station is located upstream of lagoon 15; all types liquid wastes are unloaded at this location with the exception of Zibar. The second receiving station is located at the lined Zibar lagoon (number 8). The last receiving station is located at the entrance of the landfill.

The liquid waste disposal area utilizes roughly half of the site area. There are currently 15 disposal lagoons and a Kamkha (marble production wastewater) disposal area (which has been historically used but no longer receives Kamkha) at the facility. Only one of the lagoons (Lagoon 8) is lined. The total surface area of unlined ponds equals 370,710 m^2 (based on a topographic survey done in 2011 by Amman Survey office). An additional lagoon is currently planned for construction adjacent to the main entrance of the site. A breakdown of lagoon uses is presented in Figure 2.2.

The lower lagoons (Lagoons 1 through 4) are located in the southwest corner of the site and are connected by channels or inlet pipes to facilitate equalization. Lagoon 1 is used for mixed industrial wastes, while Lagoons 2 through 4 and Lagoons 6 through 8 are used for Zibar. Furthermore, Kamkha is also disposed of in a designated area adjacent to Lagoons 3 and 4. The upper lined lagoon (Lagoon 8) was installed and brought on-line in 2010 for dedicated Zibar waste. Lagoons 6, 7 and 8 are isolated from Lagoons 1 through 4 as they are not directly connected to them and are located further to the east. Bearing in mind that Zibar waste generation is limited to the fall/winter months (October-January), site operators attempt to exercise controls to uniformly distribute the influent Zibar between Lagoons 2, 3, 4, 6, 7 and 8 such that evaporation is maximized.

Lagoon 5 currently serves as a borrow area. Lagoons 9 through 15 receive mixed industrial liquid waste, are connected either by inlet pipes or channels, and are actively used or were historically used for the mixed liquid industrial wastes. It is worth noting that Lagoons 9 and 10 serve as emergency lagoons and are only brought online when the need for overflow storage capacity arises (typically during the winter months). At the time of writing this report, Lagoons 5 through 7 and Lagoons 9 through 11 are currently dry and are not in use.

Due to their proximity to the main receiving station, Lagoons 15 and 14 have accumulated a thick layer of settled solids to the point where the liquid currently flows through a channel within the settled solids downstream through Lagoons 15 and 14 and eastwards to Lagoon 13. Within lagoon 13, the solids are allowed to continue to settle as the evaporation process continues. The decanted liquid from Lagoon 13 then flows westwards into Lagoon 12 to facilitate further sedimentation and evaporation. Lagoon 14 is brought online as needed to accommodate increases in liquid wastes delivered to the site.

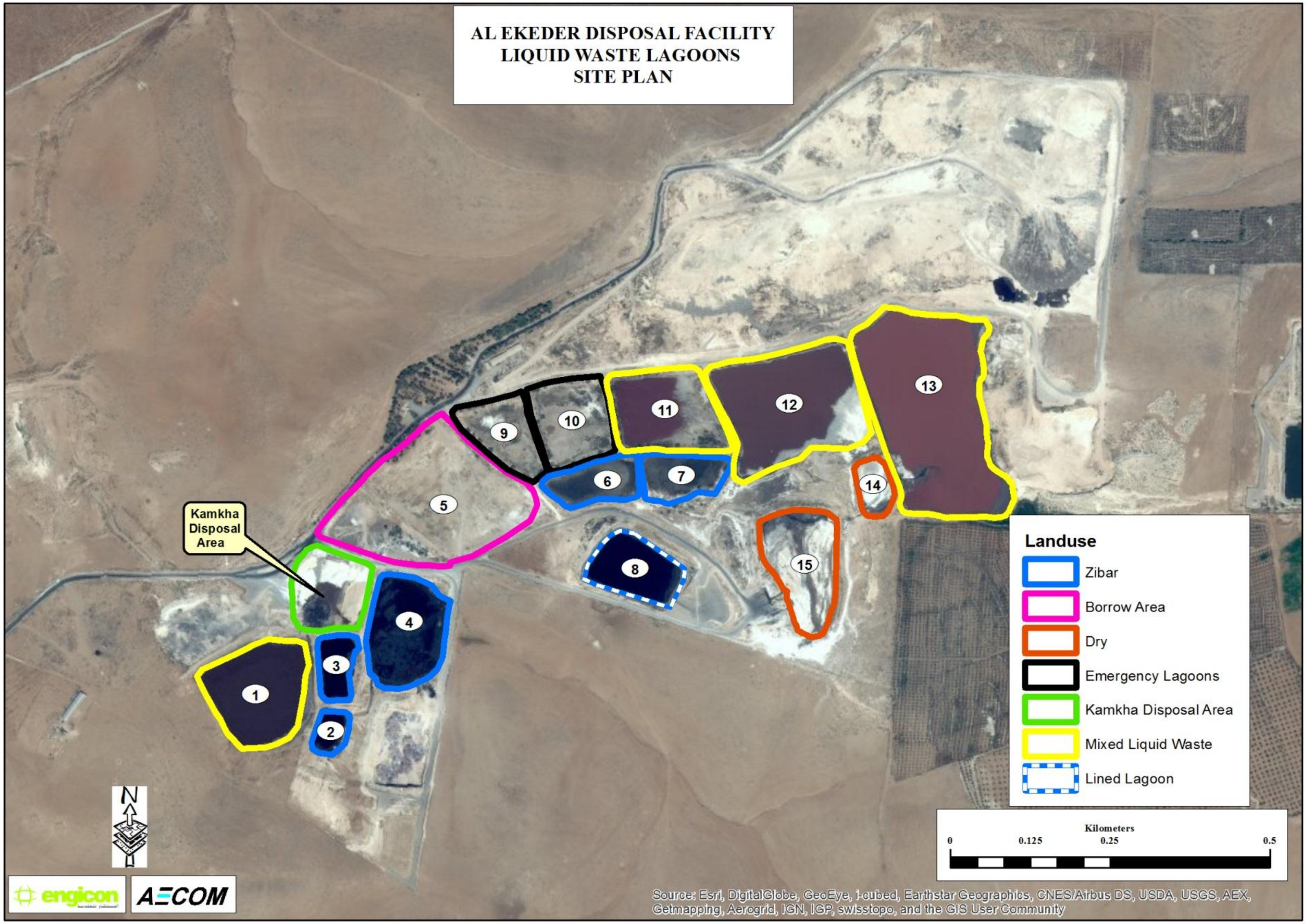

Figure 2.2: **Liquid Waste Disposal Lagoons at the Ekeder Disposal Facility**

2.2.3 Site Access

The site is connected to the Jabber Roadway, which runs along the southern boundary of the site leading to the Jabber border crossing with Syria. The Jabber Roadway links with the disposal site access road and currently has sufficient capacity to serve the facility.

Within site boundaries, there are five major access roads (see Figure 2.3)

1. Road A runs eastwards from the existing scale area along the north side of the lagoons and south side of the existing landfill.

2. Road B runs eastwards from the scale area along the north side of the Lagoon 8 to the receiving station at Lagoon 15.

3. Road C branches from Road B near the northeastern corner of Lagoon 4 and runs eastwards along the southern border of the property to the receiving station at Lagoon 15.

4. Road D also branches off Road B near Lagoon 4 and runs southwards to the southwest corner of the property.

5. Road E branches northwards off Road A near Lagoon 9 and runs north and eastwards around the existing solid waste landfill to the northeast property limit, and then southwards to the eastern termination of Road A.

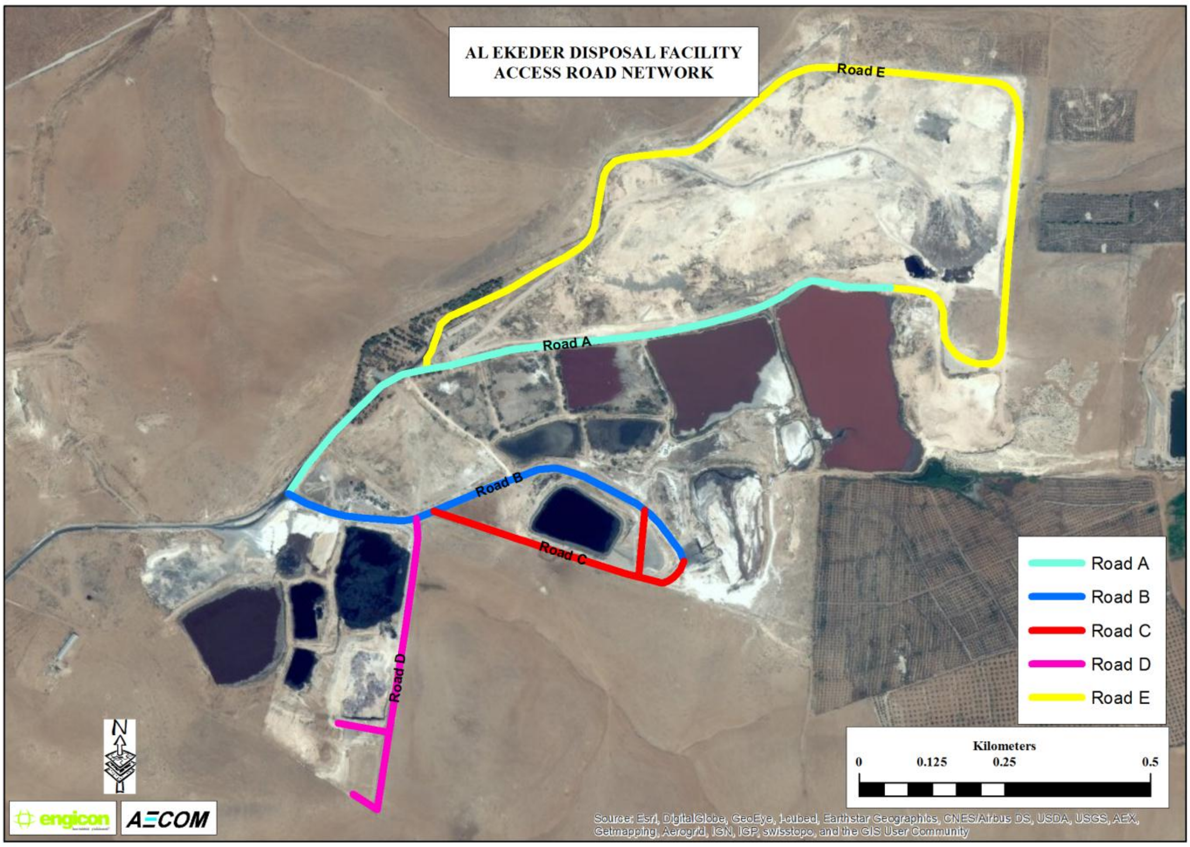

Figure 2.3: Access Road Network at the Ekeder Disposal Facility

3.0 WASTE INTAKE AND CHARACTERIZATION

3.1 Waste Intake

Record keeping at the Ekeder disposal facility is intermittent, which might render existing data unreliable. Accordingly, the project team arranged for a consultation with landfill managers on 15 October 2014. It was during this consultation that landfill operators highlighted the fact that MSW intake at the facility has increased from 900 metric tonnes per day in 2010 to 1300 metric tonnes per day – largely due to the drastic influx of Syrian refugees into refugee camps and host communities in the Northern region. Other notable waste generators in the catchment area include:

- Villages and municipalities in the North
- Farms
- Industrial areas
- Major urban centers
- Refugee camps and host communities
- Schools and Universities
- Small-scale tourism activities

Interpolation of waste intake values indicates an alarming 10% annual increase in waste generation since 2010 despite only a 2.2% annual population increase in the Kingdom (Department of Statistics, 2013)[1]. The variation between population growth and waste generation rates is indicative of the stresses on solid waste infrastructure in the North. This trend is expected to continue in the short- and medium terms as there are currently no indicators suggesting improvements in the geopolitical context of the study area in the near future. Given the region's susceptibility to absorb displaced populations, all quantity, airspace, and service-life estimates are intentionally conservative.

3.2 Waste Characterization

A waste characterization study was carried out by the project team to obtain a recent and reliable record of the waste characterization to be used for planning Ekeder development. The characterization study took into consideration the demographic and socio-economic characteristics of the waste catchment area. The test was carried out according to the ASTM D5231-92 standard for determining the composition of unprocessed MSW.

In order to obtain a representative waste characterization for the Ekeder Disposal Facility, 20 random trucks serving 20 regions in the waste catchment area were sampled[2]. Average material percentages in the obtained samples were weighted according to estimates provided by the Municipality of Irbid.

[1] Population statistics exclude non-Jordanians
[2] To account for variations in waste characteristics throughout the day, sampling was undertaken between 10 AM – 2 PM.

The determined composition of solid waste entering the Ekeder Disposal Facility is presented in Figure 3.1. The complete report can be found in Appendix B.

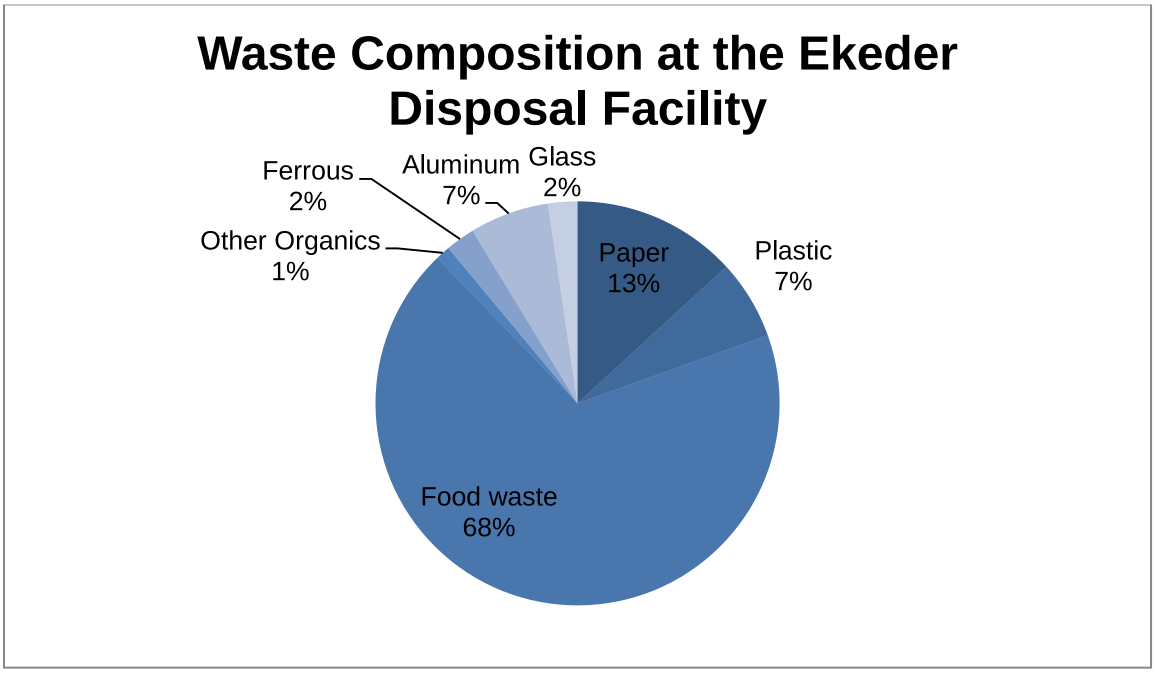

Figure 3.1: Municipal Solid Waste Composition at the Ekeder Disposal Facility

4.0 LIQUID WASTE LAGOONS

The sources of waste received by the disposal site come from about 270 locations (based on landfill records) within six governorates: Irbid, Mafraq, Jerash, Ajloun, Zarqa, and the northern part of Amman. These sources are sending both solid and liquid waste to Al-Ekeder for disposal. Liquid wastes come from the following sources:

- Wastewater treatment plant
- Textiles companies
- Dairy and milk industries
- Chicken farms
- Slaughterhouses
- Chemicals factories
- Stone and marble industries (Kamkha)
- Olive mills and companies (Zibar)
- Paper factories

The liquid waste brought to the disposal site is managed by individual private truck tankers. All of the various types of wastewater with the exception of Zibar are disposed of in the mixed liquid lagoons for treatment by sedimentation and evaporation. There is no separation process at the disposal site. Generally, these private trucks are not organized by any one single company.

4.1 Zibar

As described in Section 2.2.2, Zibar has been historically disposed of for evaporation within unlined lagoons 2, 3, 4, 6, 7, and within lined lagoon 8 (which has its own receiving station). An additional lined Zibar lagoon has been designed and is to be tendered for construction adjacent to the main entrance of the site. Lagoon 8 is completely lined with HDPE, whereas the design of the new lagoon proposes compacted clay liner for the base and HDPE liner for the sideslope areas.

4.2 Mixed Liquid Waste

As described in Section 2.2.2, mixed liquid waste (except for Zibar) has been historically disposed for evaporation within unlined Lagoons 1, 5, and 9 through 15.

5.0 VISION AND STRATEGY

The Ekeder Disposal Facility has been greatly impacted by increased waste generation in Northern Jordan over the past several years. These changes can be attributed to the introduction of new industries, urbanization, and population growth in addition to the influx of Syrian refugees into host communities and refugee camps in the Ekeder waste catchment area.

Operational capacity at the facility is increasingly stressed due to the inefficient use of available airspace (resulting from the absence of effective compaction practices) and the intake of various liquid industrial wastes for disposal in earthen lagoons occupying roughly half of the total land available. Therefore, the overall approach to future solid waste disposal operations focuses on expanding existing disposal capacity through airspace optimization; horizontal and vertical site expansion (through recent land acquisitions, and increased lift heights) and the adoption of more sustainable liquid waste treatment instead of disposal to allow utilization of additional airspace currently occupied by lagoons. Moreover, strategic construction and closure sequencing will facilitate the inclusion of engineered design interventions aimed at controlling and preventing further environmental degradation. The pursued approach to the sites rehabilitation and sustained operations is summarized in Figure 5.1.

Expansion

- Land aquisition
- Construction of new landfill cells
- Construction of a new lined Zibar lagoon

Stabilization and Rehabilitation

- Environmental controls (landfill gas, leachate management, and liner)
- Lagoon clean-up and remediation
- Intermediate and final capping

Airspace Optimization

- Liquid waste diversion to allow existing lagoons reclamation
- Lagoon closures and replacement with new landill cells
- Materials recovery facility and refuse-derived fuel

Figure 5.1: Summary of the Proposed Operational Strategy at the Ekeder Disposal Facility

The implementation of the proposed master plan breaks down into nine main engineering components, namely:

1. **Waste-fill and intermediate cover installation**
   This component involves the application of waste-fill materials to reduce side slopes to a maximum 3H:1V on all of the exterior slopes of the existing landfill. These engineered side slopes will support the addition of intermediate cover materials to isolate waste, reduce infiltration and prevent the escape of landfill gases, and provide the base grade for installation of either the ET cover or slope cap liner system (discussed below).

2. **Sanitary landfill cell construction**
   Initially, two additional landfill cells (Cells 1 and 1A) are to be constructed on adjacent land recently acquired by the facility. The construction of these additional cells will provide short-term (a minimum of 5 years) of waste disposal capacity. The proposed strategy will also enable the construction of additional future cells upon the closure of liquid waste lagoons.

3. **Slope cap construction**
   The addition of a liner system over the existing landfill will provide an impermeable barrier sloped to the new expansion cells for leachate collection and will isolate future waste disposal within a secure landfill for environmental protection.

4. **Final cap phasing**
   A proposed earthen evapotranspiration (ET) cap is to be added as a final layer of cover materials as final waste grades are reached. Final cover systems are installed at landfills to control infiltration and percolation of precipitation, to promote surface water runoff, to minimize erosion, and to control gas emissions and disease vectors – while safeguarding aesthetics and public health. ET cover systems rely on water balance and ecosystem components to reduce percolation and are typically less costly to construct than conventional cover systems that include a geosynthetic liner component (United States Environmental Protection Agency, 2003). Installation is contingent upon the soil balance of the site or other local soil availability.

5. **Infrastructure construction**
   Incorporation of environmental protection into landfill operations at the Ekeder Disposal Facility requires the construction of new landfill gas management and leachate control infrastructure. In addition to gas and leachate infrastructure, a materials recovery facility, new administrative building and a gas flare/recovery system are to be built within site boundaries.

6. **Phased liquid waste lagoon closure**
   Successful diversion of most liquid sludge by dewatering at the treatment plants and diversion of industrial liquid wastes (with the exception of seasonal Zibar) to treatment facilities would enable the closure of several existing liquid waste disposal evaporation lagoons. Closing and rehabilitating existing lagoons would enable the reclamation of land for solid waste disposal.

7. **New Zibar lagoon construction**
   The construction of an additional Zibar lagoon is proposed on recently acquired land in the Western portion of the Facility and is currently in the tendering phase. The proposed lagoon will increase Zibar intake capacity and will also allow for phased closure of other unlined Zibar lagoons and their replacement with standard lined evaporation ponds.

8. **Zibar Lagoon cleaning and lining of existing lagoons**
   The clean-up and rehabilitation of lagoons 2, 3, 6 and 7 are currently underway. The remaining unlined Zibar lagoon (lagoon 4) is to undergo similar processes. Each will be retrofitted/replaced with a standard lined lagoon.

9. **Borrow area development**
   Borrow pits are to be developed in several portions of the disposal site where appropriate to serve as a source of needed soil (earthen) cover materials. Initial estimates indicate that a soil deficit is likely to occur. Therefore, it is recommended

that external sources of soil be identified in the early phases of the implementation of the proposed Master Plan.

6.0 LANDFILL MASTER PLAN

The proposed development of the Ekeder landfill considers final waste filling over the existing landfill plateau, redevelopment of the exterior existing landfill slopes to no steeper than 3H:1V prior to final capping or slope cap construction, borrow area development, and construction of expansion Cells 1 through 6. Table 6.1 below indicates conceptual airspace (capacity), landfill base and slope cap liner systems, and ET cover volumes for each of these phases of development as of the date of the most recent aerial survey and survey updates.

Table 6.1: Conceptual Master Plan Airspace Development as of 1 November 2014

Phase or Cell Designation	Lined Area (m^2)	Gross Capacity[1] (m^3)	Liner Soil Volume[2] (m^3)	Final Cover Volume[3] (m^3)	Net Capacity[4] (m^3)
Slope Area A	N/A	3,352	N/A	N/A	3,352
Slope Area B	N/A	10,004	N/A	N/A	10,004
Slope Area 5	N/A	7,922	N/A	N/A	7,922
Slope Area 4	N/A	47,516	N/A	N/A	47,516
Slope Area 3	N/A	0	N/A	N/A	0
Slope Area 2	N/A	0	N/A	N/A	0
Slope Area 1	N/A	0	N/A	N/A	0
Plateau Fill[6]	N/A	581,904	N/A	N/A	581,904
Expansion Cell 1/1A	176,762	3,004,509	106,057	130,298	2,768,154
Expansion Cell 2	15,769	533,441	9,461	152,590	371,390
Expansion Cell 3	109,156	3,491,540	65,494	305,913	3,120,134
Expansion Cell 4	92,040	3,035,327	55,224	492,603	2,487,500
Expansion Cell 5	46,231	1,709,274	27,739	659,219	1,022,317
Expansion Cell 6	24,957	808,467	14,974	83,597	709,896
Totals	**464,915**	**13,233,256**	**278,949**	**1,824,219**	**11,130,088**

Notes:

1. *Gross Capacity has been calculated from top of closure/intermediate grades to the top of subgrade and includes daily cover soil.*

2. *Liner Soil Volume has been calculated as the Lined Area (base liner area and/or slope cap liner area) in square meters multiplied by 0.600 meters (150 mm soil cushion and 450 mm granular drainage layer). Slope cap liner has been included in expansion cell liner below each slope cap segment.*

3. *Final (ET) Cover has been calculated as the phase cap area multiplied by 1.5 meters (1350 mm soil and 150 mm protective gravel cover)*

4. *Net Capacity for waste and daily cover soil has been calculated as (Gross Capacity – Liner Soil Volume – Final Cover Volume)*

5. *Existing Slope Areas 2 and 3 require excavation/regrading to achieve maximum 3:1 grades above Access Road B.*

6. *Plateau Fill is the approximate 3.72-meter-thick lift of waste required over the existing landfill plateau to meet the required waste capacity in 2015 as Cell 1/1A is being constructed. The plateau fill design waste grades are shown conceptually on the drawings contained in Appendix D. These waste grades will need to be further analyzed during the detailed design based on current waste filling operations.*

The Landfill Master Plan is developed based on the anticipated waste intake rate and the achievable compaction (compacted waste density) at the working face. The life expectancy of a disposal cell is extended as compaction effort/efficiency improves. Table 6.2 analyzes the required 5-year disposal capacity beginning at the start of the year 2014 by varying the in-place density of the landfill waste over a typical range from “poorly” compacted (0.801 tonnes/m^3, or 50 pounds/ft^3) to “moderately well” compacted (1.121 tonnes/m^3, or 70 pounds/ft^3):

Table 6.2: Required 5-Year Landfill Capacity with Variable Waste Compaction

Year	Waste Intake[1,2] (tonnes)	Variable In-Place Waste Density (tonnes/m^3)	Waste Airspace Required (m^3)	Daily Cover[3] Required (m^3)	Total Airspace Required[4] (m^3)	Cumulative Airspace Required[4] (m^3)
1	474,500	0.801	592,441	59,244	651,685	651,685
		0.961	493,701	49,370	543,071	543,071
		1.121	423,172	42,317	465,490	465,490
2	488,735	0.801	610,215	61,021	671,236	1,322,922
		0.961	508,512	50,851	559,363	1,102,435
		1.121	435,868	43,587	479,454	944,944
3	503,397	0.801	628,521	62,852	691,373	2,014,295
		0.961	523,768	52,377	576,144	1,678,579
		1.121	448,944	44,894	493,838	1,438,782
4	518,499	0.801	647,377	64,738	712,114	2,726,409
		0.961	539,481	53,948	593,429	2,272,008
		1.121	462,412	46,241	508,653	1,947,435
5	534,054	0.801	666,798	66,680	733,478	**3,459,987**
		0.961	555,665	55,566	611,231	2,883,239
		1.121	476,284	47,628	523,913	**2,471,348**

Notes: *1. Initial disposal rate is assumed at 1300 tonnes per day, 365 days/year.*

2. Waste intake is escalated at 3% per year.

3. Daily cover has been calculated as 10% of the waste capacity required.

4. Total and cumulative airspace are calculated as waste plus daily cover.

This table shows that a “moderately well” compacted landfill would require approximately 1,000,000 m^3 less airspace than a “poorly” compacted landfill (3,459,987 m^3 – 2,471,348 m^3) over the same 5-year period for the same amount of incoming waste (waste intake). The schedule for capital outlay (earthworks and liner construction) could be extended/delayed with a commitment to an improved compaction effort at the working face during operations as less lined area is required for the same amount of incoming waste.

As indicated within Table 6.2, required capacity will depend both upon the projected waste disposal rate and the compaction efforts at the working landfill face. These will inevitably vary over time and differ from design assumptions.

Table 6.3 represents how the master plan envisions cells coming "on-line" based on the assumed waste intake, waste density and daily cover requirements. As the year 2014 had 2 months remaining during initial preparation of this report, it is assigned year "0".

Table 6.3: Conceptual Master Plan Airspace Development as of 1 November 2014

Year	Waste Intake[1,2] (tonnes)	Waste Airspace Required[3] (m^3)	Daily Cover Required[4] (m^3)	Net Capacity Required (m^3)	Cumulative Capacity Required (m^3)	Build Phase or Cell	Capacity Available[5] End of Year (m^3)
0	79,803	83,032	8,303	91,336	91,336	Ex. Landfill	559,363
1	488,735	508,512	50,851	559,363	650,699	Cell 1/1A	2,768,154
2	503,397	523,768	52,377	576,144	1,226,843		2,192,010
3	518,499	539,481	53,948	593,429	1,820,272		1,598,571
4	534,054	555,665	55,566	611,231	2,431,503	Cell 2	1,358,740
5	550,076	572,335	57,233	629,231	3,061,072		729,509
6	566,578	589,505	58,950	648,455	3,709,527	Cell 3	3,201,188
7	583,575	607,190	60,719	667,909	4,377,436		2,533,279
8	601,082	625,406	62,541	687,946	5,065,383		1,845,333
9	619,115	644,168	64,417	708,585	5,773,968		1,136,748
10	637,688	663,493	66,349	729,842	6,503,810	Cell 4	2,894,406
11	656,819	683,398	68,340	751,738	7,255,547		2,142,668
12	676,524	703,900	70,390	774,290	8,029,837		1,368,378
13	696,819	725,017	72,502	797,518	8,827,356	Cell 5	1,593,177
14	717,724	746,767	74,677	821,444	9,648,800		771,733
15	739,256	769,170	76,917	846,087	10,494,887	Cell 6	635,542
16	761,433	792,245	79,225	871,470	11,366,357		-235,928

Notes:

1. *Initial disposal rate is assumed at 1300 metric tonnes per day, 365 days/year for the year 2014 (474,500 tonnes/year). Intake from 1 November to 31 December 2014 is estimated as (474,500 tonnes x 2/12 = 79,083 tonnes) as year 0.*
2. *Waste intake is escalated at 3% per year.*
3. *In-place density estimated between "poorly" and "moderately well" as (0.961 tonnes/m^3, or 60 pounds/ft^3).*
4. *Daily cover has been calculated as 10% of the waste capacity required.*
5. *Available capacity is taken from Table 6.1.*

Continued development of the existing disposal areas and construction of new lined disposal areas will require soils for use as daily cover soils (unless alternative materials such as re-usable tarps are utilized) and for construction of the landfill base grades (subgrade). While some of these operational and construction soils may be available from on-site borrow areas and from excavation associated with new cell construction, additional off-site sources should be identified. Table 6.4 presents the conceptual soil balance for proposed Expansion Cells 1 through 6 and slope cap areas.

Table 6.4: Conceptual Soil Requirements for Cells 1-6

Phase or Cell	Construction				Operations	Closure	
	Subgrade Cut (m^3)	Subgrade Fill (m^3)	150mm Liner Cushion (m^3)	450mm Granular Layer (m^3)	Daily Cover (m^3)	1350mm ET Cover (m^3)	150mm Gravel Cover (m^3)
Fill Slope A	0	0	0	0	335	0	0
Fill Slope B	0	0	0	0	1,000	0	0
Fill Slope 5	0	0	0	0	792	0	0
Fill Slope 4	0	0	0	0	4,752	0	0
Fill Slope 3	0	0	0	0	0	0	0
Fill Slope 2	0	0	0	0	0	0	0
Fill Slope 1	0	0	0	0	0	0	0
Plateau A	0	0	0	0	26,505	0	0
Plateau B	0	0	0	0	22,058	0	0
Plateau C	0	0	0	0	9,628	0	0
Cell 1/1A	219,608	122,046	26,514	79,543	276,815	117,268	13,030
Cell 2	221,151	18,076	2,365	7,096	37,139	137,331	15,259
Cell 3	72,952	67,510	16,373	49,120	312,013	275,322	30,591
Cell 4	108,704	5,281	13,806	41,418	248,750	443,343	49,260
Cell 5	283,619	20,180	6,935	20,804	102,232	593,297	65,922
Cell 6	77,502	157,769	3,744	11,231	70,990	75,237	8,360
Totals	983,536	390,862	69,737	209,212	1,113,009	1,641,798	182,422

Construction soils are required for formation of the disposal cell subgrade and for the liner cushion layer of the base liner system. It can be assumed that excavated soils (subgrade cut) may be used as compacted fill (subgrade fill) to form the landfill base grades and berms. It is assumed that the 150mm liner cushion layer may also be constructed from processed/crushed excavated soil (subgrade cut). The 450mm granular layer (protective cover) meeting the project specifications would be obtained from off-site sources(s).

Operations soils consist of the 150mm (minimum) thick layer of daily cover material installed at the end of each work day. Within the table, daily cover has been estimated as 10% of the total available airspace volume in each development phase. This material may be constructed from excess subgrade cut material or from dry sludge excavated during lagoon remediation/cleanup. Airspace use may also be maximized through the use of alternate daily covers such as impermeable tarps that may be removed and re-installed on a daily basis.

Closure soils consist of the 1350mm thick ET cover and the 150mm thick gravel stabilization layer. While the ET cover soil may be constructed from excavated soil (subgrade cut), the 150mm granular layer meeting the project specifications would be obtained from off-site sources(s).

Based on the proposed phasing sequence and estimates above, there is sufficient on-site soils to construct the subgrade and liner cushion layer for Cells 1/1A from soils excavated from the Cell 1/1A footprint area (219,608 – 122,046 – 26,514 = 71,048 m^3). The remaining Cell 1/1A subgrade cut and the excavated dry sludge from the lagoons (71,048 + 94,371 = 165,419 m^3) could be used to fulfill part of the 150mm thick daily cover soil requirement for Cell 1/1A. The balance of daily cover and the 1350mm thick ET cover layer required for Cell 1/1A (276,815 – 165,419 +117,268 = 228,664 m^3) could be excavated from the western borrow area (lagoons 5,6,9 and 10), from the recently acquired properties (lots 45 through 47) along the eastern edge of the facility, from the Cell 2 construction area, from the new Zibar lagoon construction, or off-site sources.

It is recommended that off-site borrow sources be identified at around year 4 during Cell 1/1A waste filling. In the longer term, beyond 5 years after the construction of Cells 1/1A, Ekeder landfill will experience soil deficits. The soil needs are shown on Table 6.4 and the off-site sources of soil should be identified prior to the construction of Cell 3 in the current wastewater lagoon 13 area.

6.1 Short Term (1-5 Years)

The majority of the landfill construction activities discussed in Section 5.0 require immediate action in the short term. Preliminary phasing of the proposed strategy necessitates that waste-filling and grading (i.e. pile reshaping) is undertaken prior to the construction of the first new cell on the newly acquired land plots in the eastern portion of the site (Cell 1 and 1A). Slope Areas A and B are to be filled/reshaped to slopes no steeper than 3H:1V before the existing access road along the eastern edge of the landfill is removed.

Based on waste projections, a cumulative capacity of 650,699 m^3 of capacity is required from November 2014 (Year 0) through the end of 2015 (Year 1). It is assumed that waste filling over the existing landfill plateau (conceptually, an approximate 3.72 meter lift over the approximate 156,426 m^2 area) and filling to maximum 3:1 slope grades upwards from the existing landfill access road in Fill Slope Areas 1-5 and A-B will accommodate capacity requirements through the close of 2015 (Year 1). Therefore, Cell 1/1A and Slope Cap Area A must be constructed and ready for waste acceptance by the end of 2015 (Year 1).

Preliminary sequencing of activities (see Table 9.1) for the short term also indicate that Cell 2 must be constructed and ready to accept waste near the end of 2018 (Year 4).

In addition to Cell 1/1A and Cell 2 construction, this Master Plan envisions that the existing landfill would be completely covered with intermediate cover (interior slope and existing landfill plateau) and the final evapotranspiration cover over Cap Phase A and B (external slopes that are not affected by overlay of the expansion areas) in by the end of 2016 (Year 2)

Comprehensive sequencing of work activities is presented in Section 9 of this document.

6.2 Long Term (5-20 Years)

The short-term interventions presented in Section 6.1 lay the ground work for a more integrated approach to the optimization of airspace at the Ekeder Disposal Facility. The sequencing of long-term solid waste disposal operations is contingent on the soil balance available with every passing year, requirements for continued Zibar/liquid waste storage, and anticipated waste intake rates.

The post-five-year development plan includes the construction of five additional sanitary landfill cells (cells 2 through 6) provided that the liquid waste diversion and lagoon closures are implemented within the timeframe specified in sections 7 and 9 of this document. The construction of these additional cells would include the construction of the landfill perimeter berm within or through or in portions of or in the entirety of lagoons 6, 7, 11, 12, 13, 14 and 15.

7.0 LIQUID WASTE AND ZIBAR LAGOON MASTER PLAN

As indicated above, the existing industrial liquid waste and Zibar lagoons are currently in the planning or action stage of cleaning and rehabilitation for continued use or will be closed and removed from service. Closure and removal from service will allow for the optimization of available airspace for solid waste disposal and/or use of borrow soils. A summary of the remediation activities for each lagoon is provided on Table 7.1.

Table 7.1: Summary of Proposed Liquid Waste Lagoon Remediation/Closure Activities at the Ekeder Disposal Facility

Lagoon	Contents	Wastewater to be Removed (m^3)	Wet Sludge to be Removed (m^3)	Dry Sludge to be Excavated (m^3)	Proposed Action
1	Mixed Waste	140,468	N.A	N.A	to be evaporated
2	Zibar	0	N.A	N.A	to be cleaned
3	Zibar	20,603	N.A	N.A	to be cleaned
4	Zibar	17,631	N.A	N.A	to be cleaned
5	Borrow pit	0	0	0	no action
6	Zibar	0	0	8,313	to be cleaned
7	Zibar	0	0	7,016	to be cleaned
8	Zibar	0	0	0	no action
9	Emergency	0	0	0	no action
10	Emergency	0	0	8,7210	no action
11	Mixed Waste	22,937	4,150	0	to be closed and remediated
12	Mixed Waste	69,550	28,780	0	to be closed and remediated
13	Mixed Waste	140,000	40,000	0	to be closed and remediated
14	Filled with Sediments	0	0	7,066	to be closed and remediated
15	Filled with Sediments	0	0	63,255	to be closed and remediated
Kamkha	Kamkha	N.A	N.A	N.A	no action

N.A: Not Applicable

7.1 Short Term (1-5 Years)

Diversion of all liquid wastes (with the exception of Zibar) for off-site wastewater treatment would allow for the initiation of lagoon closures and the optimization of available airspace for solid waste disposal. For the industrial waste lagoons, the short-term plan includes remediation and removal of lagoon 13 within the first 4 years to allow for construction of solid waste Cell 3 which is planned at Year 4.

Currently, work is in progress to construct two interconnected lined Zibar lagoons on recently acquired land in the Western portion of the site adjacent to the site entrance. The new lined lagoons are currently in the tendering phase and will provide additional Zibar intake capacity to partially replace the current practices of disposal in unlined lagoons. These new lagoons will reduce the incoming Zibar flow to the existing lagoons which will allow for remediation of the remaining existing Zibar lagoons in accordance with internationally recognized environmental standards within five years.

Clean up work in four existing lagoons (Lagoons 2, 3, 6, and 7) is currently underway to create space for Zibar flow for the 2014–2015 season. Beyond the 2014-2015 season, plans are in place to gradually expand remedial efforts to rehabilitate the remaining Zibar lagoons. Currently the plan is to allow the Rajhi cement factory to drain the liquid and excavate the sediment Zibar for use at the cement factory as an alternative fuel source.

7.2 Long Term (5-20 Years)

To allow for the landfill expansion to proceed as planned for the coming 15 years, Lagoons 7, 11, 12, 14, and 15 must be remediated and removed by Year 8 to allow for construction of MSW Cells 4, 5, and 6. The intake of all industrial liquid wastes (with the exception of Zibar) is planned to be halted completely after the first five years. Doing so would allow for the complete closure and removal of liquid waste lagoons as needed for reuse as a solid waste landfill disposal footprint. Lagoons 5, 6, 9, and 10 are not currently within the expansion footprint and could be used as soil borrow pits or serve as emergency lagoons until the practice of liquid waste disposal is stopped.

8.0 ACCESS AND INFRASTRUCTURE PLAN

8.1 Access Plan

Existing Roads A and E will continue to be used for access to the existing solid waste disposal area and will be connected to the Cell 1/1A perimeter access road. The north to south portion of Road E will remain active until slope filling along the eastern limit of the existing landfill is complete. Anchor trenches for the slope cap and cell floor liner systems will be aligned along the existing road.

Prior to Cell 2 construction, a short segment of Road E will be removed and temporarily relocated westwards along the eastern edge of lagoon 13. This temporary road will be taken out of service prior to Cell 3 construction.

Prior to Cell 3 construction, Road C will be extended around the southern property edge from the current Roads B&C termination at Pond 1 for construction access.

8.2 Scale Facilities and Office

The existing scale equipment and building will be relocated westwards along the access road leading to the Ekeder disposal facility to eliminate traffic congestion/conflicts in the vicinity of the proposed Zibar lagoons and to minimize potential odor nuisance exposure to scale facility personnel. A new administration office will be constructed near the southeast corner of existing lagoon 15.

8.3 Gas Management Facilities

Landfill gas utilization/re-use equipment and a backup landfill gas flare station will be constructed within the infrastructure area to the east of existing lagoon 13.

8.4 Equipment Maintenance Area

The liquid waste unloading area at lagoon 15 could serve as the new equipment storage/maintenance area once liquid waste has completely stopped and this receiving area is no longer needed.

8.5 Materials Recovery Facility (MRF) and Refuse Derived Fuel (RDF) Facility

An enclosed Materials Recovery Facility (MRF) is proposed in the Northern part of the newly acquired land, near the tie-in of proposed Cell 1 to existing Access Road E on the north side of the facility. The MRF will generally consist of an enclosed building with a concrete tipping floor of sufficient size to accommodate the following: multiple incoming waste hauling vehicles (number to be determined); maneuvering space for a wheeled loader to transfer tipped waste to the recovery area; materials handling/sorting equipment such as screens, magnets, conveyors, and crushers/compactors/balers; storage area(s) for separated recovered material; and a load-out area for loading vehicles with waste materials to be disposed of at the landfill and for loading recovered materials onto vehicles for transfer to end market users. If determined to be economically feasible, a Refuse Derived Fuel (RDF) Facility may also be developed within the same general area as the MRF. The RDF Facility could be designed as an adjacent standalone facility or incorporated into the MRF operations layout.

8.6 Leachate Collection and Evaporation Lagoons

Leachate collection sumps will be constructed at the low point of each new lined disposal cell to allow for pumping leachate to new storage/evaporation lagoon(s). A leachate forcemain will be constructed within a utility corridor on the new perimeter berm to convey leachate from each cell to the evaporation lagoon(s). The lagoon(s) will be constructed in the proposed infrastructure area east of existing lagoon 13 to contain pumped leachate from the proposed slope-cap-lined areas and new lined disposal cells. Only passive/natural evaporation from exposure of the contained water surface to solar radiation and wind is proposed. No additional enhanced evaporation by hydraulic/mechanical means such as sprinklers, misters, or aerators is proposed. For added conservatism, evaporation of stored water will not be accounted for in leachate lagoon sizing. The leachate lagoon(s) will be lined with a geosynthetic liner system equivalent to the liner system proposed for the new landfill cells and will be anchored at the lagoon crest.

8.7 Erosion and Sedimentation Control and Stormwater Management

A lined drainage channel will be incorporated into the design of the proposed perimeter berm to convey runoff from the developing landfill final grades as well as the perimeter access road to one of several stormwater management basins/areas as described below.

A new northern stormwater management basin will be required near the tie-in of proposed Cell 1 to existing Access Road E to manage runoff from a portion of Cell 1 and the proposed MRF.

A stormwater management/infiltration basin will be required along the eastern edge of proposed Disposal Cell 1 within the existing valley feature to contain at least a portion of the runoff from Cell 1 and the runon from drainage areas east of the landfill site. It is anticipated that at least the lower elevations of this basin along the toe of the perimeter berm will be lined with an impermeable geomembrane; this will ensure that collected stormwater does not undermine the newly constructed Cell 1 perimeter berm and will allow for enhanced infiltration away from the perimeter berm.

A new stormwater management basin will be required in the vicinity of the southern edge of proposed Cell 1A to manage runoff collected within the perimeter channel of proposed Cells 1, 1A and a portion of Cell 2.

Existing lagoon 15 will be decommissioned and its southern portion will be converted into a stormwater management basin to manage runoff collected within the perimeter channel of proposed Cells 2, 3, and the southern edges of proposed Cells 5 and 6.

The western edge of the existing landfill and runoff collected within the perimeter channel along the northern edge of proposed Cell 5 and the western and northern edge of Cell 6 will drain to a stormwater management pond/area north of existing lagoons 10 and 11.

8.8 Borrow Area and Stockpiling

Lagoons 5, 6, 9 and 10 located at the western side of the facility will be remediated and used for soil borrow and stockpiling activities. In the event that emergency storage of liquid waste is required, all or portions of the footprint encompassed by this area may be used for temporary unlined liquid waste storage.

Recently acquired properties along the eastern edge of the facility (lots 45 through 57) will be excavated for borrow soils to be used for construction of Cells 1A and 1B. They will also be used for temporary storage of excess soils for future cell construction.

9.0 SEQUENCING OF CONSTRUCTION

9.1 Support Areas and Cell Construction

9.1.1 Short Term (1-5 Years)

Short-term work activities related to cell and infrastructure construction can be classified into seven core components to as shown in Figure 9.1.

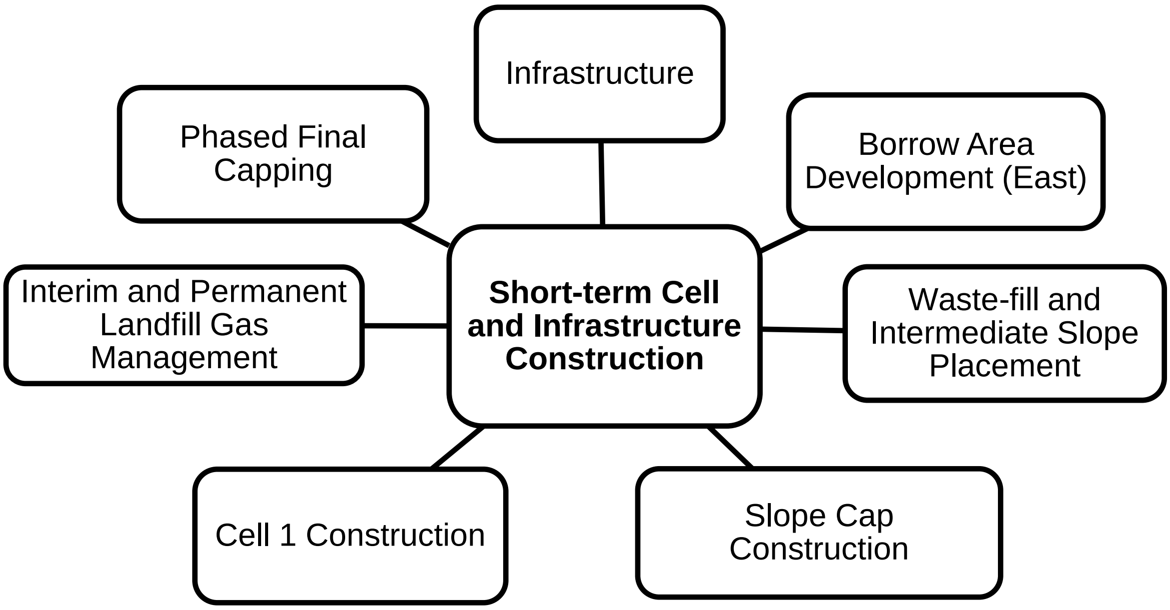

Figure 9.1: **Schematic Summary of Short-term Work Activities pertaining to Cell and Infrastructure Construction**

Infrastructure

The infrastructure component is planned to commence within Year 1 (2015) of Master Plan implementation and incorporates the construction of a Materials Recovery Facility (MRF) in the northern part of the site, leachate lagoon(s), the relocation of the administrative office and the scale house, and utilities associated with Cells 1/1A and 2 (leachate sumps and force main, perimeter gas header pipe, electrical conduits and cable, erosion and sedimentation control systems). Infrastructure development is to be prioritized in order to facilitate sustainable landfill operations and the achievement of the long-term Master Plan objectives as outlined in Section 5 of this document.

Borrow Area Development

In tandem with the construction of core infrastructure and Cell1/1A at the Ekeder Disposal Facility (i.e., Year 1 or 2015), it is recommended that the western borrow area (which currently accommodates lagoons 5, 6, 9, and 10) be developed so that soil materials can be accessed to facilitate cell construction and phase capping over several years. Corresponding work activities include topsoil stripping, excavation, stockpiling of cover materials and the possible construction of an on-site crushing and screening plant, in addition to effective drainage controls. Borrow area development and stockpiling activities are expected to take place over the course of facility service life. As described in Section 8.8, other borrow soils for cell construction may be excavated from recently acquired lots 45 through 57 along the eastern edge of the facility.

Waste Fill and Intermediate Slope Placement

Current side slopes of the solid waste pile at the existing landfill are highly irregular and are ill-suited for future development activities (i.e. vertical expansion of the existing facility or post-closure development). As such, the stabilization of side slopes has been identified as a crucial component of the remedial Master Plan, and can be integrated with current operations at the working face of the existing landfill. Existing Slope Areas A and B and Slope Area 1-5 are to undergo additional compacted waste placement to help meet capacity requirements in Year 1 (2015) and to stabilize the slopes to a maximum slope of 3H:1V prior to installation of intermediate cover. This will form the base for future slope cap liner construction.

As indicated previously, it is also assumed that waste filling over the existing landfill plateau (approximate 3.72 meter lift over the approximate 156,426 m^2 area) is also required to meet the capacity requirements through the close of Year 1 (2015) as Cell 1/1A and Slope Cap Area A are being constructed.

Modifications to current practices at the working face of the landfill will involve re-introducing compaction equipment to support waste lift development and modern landfilling practices including daily and intermediate slope covers. The overlap between some side slopes of the existing landfill and the new proposed cells necessitate that all waste-fill practices and covers (including the slope cap outlined below) are completed prior to the construction of the overlapping cells.

Slope Cap Construction

A slope cap liner system is proposed for installation above all interior surfaces of the existing landfill that will receive additional waste during expansion filling (initially Slope Cap Area A). Prior to the installation of the proposed geosynthetic slope cap liner system, a cushion layer (maximum particle size <=20mm) and anchor trench are to be constructed to prevent damage to the geosynthetic materials and hold them in place. The slope cap liner system would typically be installed in parallel with the new expansion cell liner system(s) for Cell 1/1A as the anchor trenches along the toe of the slope cap and crest of the Cell 1/1A liner are integrated to provide a continuous barrier.

Cell 1/1A Construction

Following the acquisition of adjacent land plots, landfilling activities are to be expanded with the addition of a new sanitary cell (hereafter referred to as Cell 1/1A) intended to provide approximately five years of airspace. Construction of Cell 1/1A will consist of the following sub-tasks:

1. Bringing in the required equipment and the placement of materials
2. Establishment of a pumping basin for effective storm water management
3. Clearing and grubbing of newly acquired land plots
4. Stripping of topsoil
5. Subgrade excavation and maximum slope grading
6. Subgrade fill and grading of minimum and maximum slopes
7. Construction of main perimeter berm, access road, litter fence and guard rail
8. Perimeter utility corridor development (force main, electric, gas header and valves)
9. Construction of inter-cell berm to separate sub-cells 1 and 1A.
10. Addition of the liner cushion system (particle size <=20mm)
11. Construction of perimeter anchor trench
12. Installation of the geosynthetic liner system
13. Construction of leachate collection sump and side-slope riser
14. Addition of protective cover materials
15. Installation of leachate collection pipe network
16. Construction of perimeter drainage channels

Given the sense of urgency to expand the capacity of the existing facility, it is highly recommended that Cell 1/1A construction be undertaken as soon as possible. It is important that the slope cap above Cell 1 (Slope Cap Area A) should be prepared and ready for liner as Cell 1/1A is lined in order to minimize potential conflicts with cell construction and waste compaction equipment, and to maximize available airspace in Cell 1/1A (i.e. waste overlaying the slope cap).

Interim Landfill Gas Management
Interim landfill gas management is crucial to mitigate potential odor emissions during cell service life. Interim landfill gas management infrastructure is temporary in nature and is often retrofitted with permanent components following the closure of a landfill cell. Work activities associated with the interim landfill gas management systems will include excavation of trenches, backfilling with porous material and perforated collection piping, installation of trench heads, installation of temporary vertical wells and well heads where appropriate, and installation of a network of temporary transmission piping.

Permanent Landfill Gas Management
When the maximum anticipated waste grades have been achieved and after intermediate cover has been placed, the interim gas collection/transmission features should be replaced with or be upgraded to function as permanent fixtures and additional permanent wells drilled. Work activities associated with this component will involve upgrading the temporary vertical wells, well heads and transmission piping with more permanent counterparts.

Phased Final ET Cover
As mentioned in Section 5 of this document, an earthen evapotranspiration (ET) cap is to be added as the final component of landfill construction. The installation of this final cover is to be phased in accordance with the quantities of soil available. Work activities associated with the installation of the final ET cover will include

1. Bringing in the required equipment and the placement of materials
2. Placement of 300 mm intermediate cover
3. Placement of 1050 mm evaporative soil layer
4. Placement of 150 mm gravel protection layer
5. Construction of an access road and drainage channel(s)

It is anticipated that Phases A and B of the proposed ET cap over the existing landfill can be installed within the first five years of Master Plan implementation as they are areas that will not be effected by expansion filling and will not require a slope cap liner system. Phased final capping can be deemed complete when the top surface has been covered and stabilized/protected with 150 mm of gravel. ET cap installation is therefore expected to be a continuous process over the service life of the facility.

Cell 2 Construction
Construction of Cell 2 will be initiated in Year 4 (2018) following completion of Fill Slope Area 5 and will consist of the following sub-tasks:

1. Bringing in the required equipment and the placement of materials
2. Clearing and grubbing
3. Stripping of topsoil
4. Subgrade excavation and maximum slope grading
5. Subgrade fill and grading of minimum and maximum slopes
6. Construction of main perimeter berm, access road, litter fence and guard rail
7. Perimeter utility corridor development (force main, electric, gas header and valves)
8. Construction of inter-cell berms to separate adjacent cells

9. Addition of the liner cushion system (particle size <=20mm)
10. Construction of perimeter anchor trench
11. Installation of the geosynthetic liner system
12. Construction of leachate collection sump and side-slope riser
13. Addition of protective cover materials
14. Installation of leachate collection pipe network
15. Construction of perimeter drainage channels

Based on technical considerations and anticipated resource availability, the proposed sequencing of work activities for the short-term is presented in Table 9.1. Year 1 is assumed to be the year 2015.

Table 9.1: Proposed Sequencing of Short-Term Landfill Activities

Year	Work Activities	Sequencing Dependence
1	Existing landfill plateau filling	
	3H:1V waste filling in Slope Areas A-B and 1-5	
	Construction of pumping basin and MRF basin	
	Borrow Area development (E&S, screening, stripping, stockpiling)	
	Construction of Cell 1 subgrade, perimeter berm, utility corridor, channel and road	
	Construction of Cell 1 base liner system, sump, side slope risers, and pumping system	
	Construction of Slope Cap Area A	
	Construction of Infrastructure (MRF, LFG management facility, office building, leachate lagoons)	
	Relocation of facility entrance	
2	Construction of Cell 1A subgrade, perimeter berm, utility corridor, channel and road	
	Construction of Cell 1A base liner system, sump, side slope risers, and pumping system	
	Construction of Cell 1A stormwater management basin	
	Phased closure of existing landfill Phases A-B and Expansion Cell 1 and gas system installation	
3	Lagoon 13 Remediation and Connection of Lagoon 14 to Lagoon 12	
	Phased closure of Expansion Cells 1 and 1A and gas system installation	
4	Closure of a portion of Road E and construction of temporary road adjacent to Lagoon 13	
	Construction of Cell 2 subgrade, perimeter berm, utility corridor, channel and road	Remediate lagoon 13
	Construction of Cell 2 base liner system, sump, side slope risers, and pumping system	
	Construction of Slope Cap Area B	
	Construction of new roads along south side of lagoons 15 and 13	
	Phased closure of Cells 1 and 1A and gas system installation	
5	Phased closure of Cells 1, 1A and 2 and gas system installation	

9.1.2 Long Term (5-20 Years)

Long-term work activities related to cell and infrastructure construction can be classified into four core components to as shown in Figure 9.2

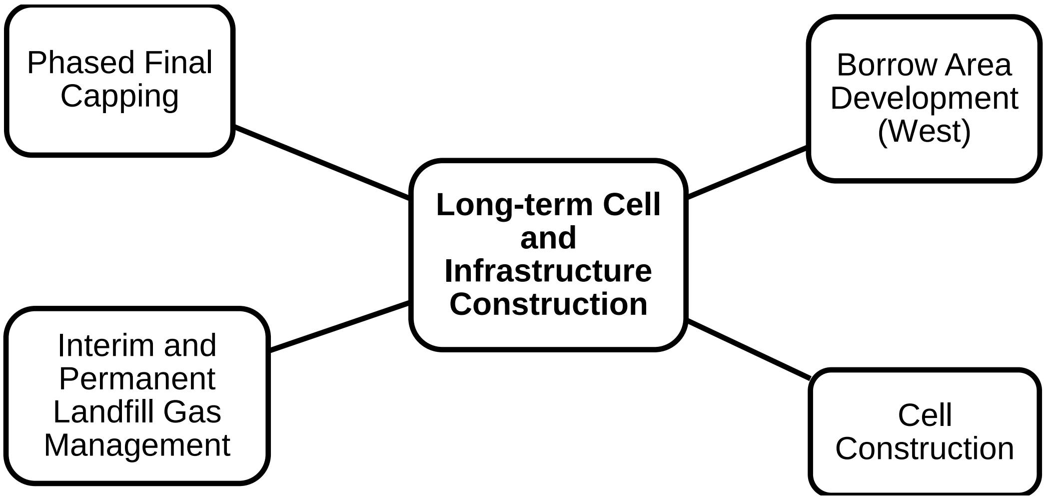

Figure 9.2: **Schematic Summary of Long-term Work Activities pertaining to Cell and Infrastructure Construction**

Borrow Area Development

Continue borrow area development in phases to allow for the use of some portions as emergency liquid waste lagoons when needed. Ultimately, this area is envisioned to be filled with stockpiled soils (resulting from excavation during cell construction) and serve as a borrow area during the implementation of long-term landfill activities as identified in Table 9.2.

Cell Construction

Following the closure (and remediation) of existing liquid waste lagoons, landfilling activities are to be expanded with the addition of new sanitary landfill cells 3 through 6 on reclaimed/ remediated land. Cell construction will encompass the following sub-tasks:

1. Bringing in the required equipment and the placement of materials
2. Clearing and grubbing
3. Stripping of topsoil
4. Subgrade excavation and maximum slope grading
5. Subgrade fill and grading of minimum and maximum slopes
6. Construction of main perimeter berm, access road, litter fence and guard rail
7. Perimeter utility corridor development (force main, electric, gas header and valves)
8. Construction of inter-cell berms to separate adjacent cells
9. Addition of the liner cushion system (particle size <=20mm)
10. Construction of perimeter anchor trench
11. Installation of the geosynthetic liner system
12. Construction of leachate collection sump and side-slope riser
13. Addition of protective cover materials
14. Installation of leachate collection pipe network
15. Construction of perimeter drainage channels

Work activities associated with lagoon closure and rehabilitation are presented in Section 9.2 of this document.

Interim Landfill Gas Management

Interim landfill gas management is crucial to mitigate potential odor emissions during cell service life. Interim landfill gas management infrastructure is temporary in nature and is often retrofitted with permanent components following the closure of a landfill cell. Work activities associated with the interim landfill gas management systems will include excavation of trenches, backfilling with porous material and perforated collection piping, installation of trench heads, installation of temporary vertical wells and well heads where appropriate, and installation of a network of temporary transmission piping.

Permanent Landfill Gas Management

When the maximum anticipated waste grades have been achieved and after intermediate cover has been placed, the interim gas collection/transmission features should be replaced with or be upgraded to function as permanent fixtures and additional permanent wells drilled. Work activities associated with this component will involve upgrading the temporary vertical wells, well heads and transmission piping with more permanent counterparts.

Phased Final Capping

As mentioned in Section 5 of this document, an earthen evapotranspiration (ET) cap is to be added as the final component of landfill construction. The installation of this final cover is to be phased in accordance with the quantities of soil available. Work activities associated with the installation of the final ET cover will include

1. Bringing in the required equipment and the placement of materials
2. Placement of 300 mm intermediate cover
3. Placement of 1050 mm evaporative soil layer
4. Placement of 150 mm gravel protection layer
5. Construction of an access road and drainage channel(s)

Phased final capping can be deemed complete when the top faces of all existing and newly constructed cells (in addition to their respective outer side slopes) are covered and stabilized/protected with 150 mm of gravel. ET cap installation is therefore expected to be a continuous process over the service life of the facility. The capping of newer cells will take place upon (or shortly after) their respective closures.

Based on technical considerations and anticipated resource availability, the proposed sequencing of work activities for the long-term (Year 6 and onwards) is presented in Table 9.2. Year 6 is assumed to be the year 2020.

Table 9.2: **Proposed Sequencing of Long-Term Landfill Activities**

Year	Work Activities
6	Relocate entrance to infrastructure/maintenance area
	Construct Stormwater Basin at Lagoon 15
	Construct Cell 3 subgrade, perimeter berm, utility corridor, channel and road
	Construct Cell 3 base liner system, sump, side slope risers, and pumping system
	Construct Slope Cap Area C
7	Phased closure of Cells 1-3 and existing landfill overlay areas, gas system installation
8	Phased closure of Cells 1-3 and existing landfill overlay areas, gas system installation
9	Phased closure of Cells 1-3 and existing landfill overlay areas, gas system installation
10	Construct Cell 4 subgrade, perimeter berm, utility corridor, channel and road
	Construct Cell 4 base liner system, sump, side slope risers, and pumping system

	Construct Slope Cap Area D
	Phased closure of Cells 1-3 and existing landfill overlay areas, gas system installation
11	Phased closure of Cells 1-4 and existing landfill overlay areas, gas system installation
12	Phased closure of Cells 1-4 and existing landfill overlay areas, gas system installation
13	Construct Cell 5 subgrade, perimeter berm, utility corridor, channel and road
	Construct Cell 5 base liner system, sump, side slope risers, and pumping system
	Phased closure of Cells 1-4 and existing landfill overlay areas, gas system installation
13	Phased closure of Cells 1-5 and existing landfill overlay areas, gas system installation
14	Phased closure of Cells 1-5 and existing landfill overlay areas, gas system installation
15	Construct Cell 6 subgrade, perimeter berm, utility corridor, channel and road
	Construct Cell 6 base liner system, sump, side slope risers, and pumping system
	Phased closure of Cells 1-5 and existing landfill overlay areas, gas system installation
	Design Future Cell 7
16	Phased closure of Cells 1-6 and existing landfill overlay areas, gas system installation
	Construct Cell 7
17	Phased closure of Cells 1-7 and existing landfill overlay areas, gas system installation

9.2 Liquid Waste and Zibar Remediation

9.2.1 Short Term (1-5 Years)

As outlined in Section 5 of this document, the overall approach to liquid waste management at the Ekeder Disposal Facility involves:

- Restricting liquid waste intake to Zibar only
- Phased closure of liquid waste lagoons for reclamation and redevelopment as sanitary landfill cells (beginning with lagoon 13)
- Construction of the new lined Zibar lagoon to allow for phased rehabilitation and retrofitting of existing unlined Zibar lagoons

Initial time estimates indicate that all requisite work activities can be completed in the short term to allow for sustained landfilling operations over the long term. At the time of writing this report, work is currently underway to clean lagoons 2, 3, 6 and 7. Current clean-up operations have been integrated into the Master Plan and have been included in this document. The proposed sequencing of the required work activities is presented in Table 9.3. Year 1 is assumed to be the year 2015.

Table 9.3: Proposed Sequencing of Short-Term Liquid Waste and Zibar Activities

Year	Work Activities	Sequencing Dependence
1	Divert all liquid waste to new industrial WWTP	Creating successful alternatives for liquid waste treatment
	Complete cleanup of lagoons 2, 3, 6 and 7	
	Construct new Zibar lagoons	
2	Evaporate liquid in Lagoon 1	
	Line lagoons 2 and 3	
	Clean up lagoon 4	
3	Closure and remediation of lagoon 13	
4	Closure and remediation of lagoons 15, 7, and 11	
5	Closure and remediation of lagoon 12	

9.2.2 Long Term (5-20 Years)

All of the remaining Zibar lagoons will be converted to lined facilities if it is determined that Ekeder will continue to be utilized for Zibar disposal in the long run.

10.0 OPERATIONS REQUIREMENTS, CONSUMABLES, AND STAFFING

10.1 Personnel Training

Current and new landfill employees should be briefed and trained on landfill history and operations procedures and will attend (at a minimum) an initial safety orientation meeting with site management. Equipment operators and laborers will be instructed on the importance of the liner system as related to environmental protection and educated in operational procedures that will prevent liner system damage or failures. Additionally, operations personnel selected for potential employment will be required to take a comprehensive physical examination prior to employment.

All personnel will receive basic safety training relating to facility operations. This training will include procedures to be following during an emergency, locations of emergency and first aid equipment, and facility notification procedures.

Depending on a person’s actual job functions, additional training may also be warranted. This additional training may involve familiarization with the facility design and operational plans to ensure proper procedures are followed. Similarly, training may be provided regarding applicable local regulations pertaining to the facility as well as associated environmental protection features used at the site. Records that document the personnel training will be maintained at the facility. The records will indicate the content of the program and dates on which training was received. The records will be maintained throughout each individual’s employment at the facility.

10.2 Disposal Operations

Waste will typically be placed within each cell in horizontal lifts not exceeding 2.5 meters in height. Incoming waste will typically be spread and compacted with a bulldozer (or optimally with heavy compaction equipment) in approximate 500-mm-thick layers up to the 2.5 m lift height. A “spotter” or the lead operator will direct vehicles to the appropriate disposal location. Deposited waste will be sloped inwards and away from developing exterior finished slopes. The size of the working face will be controlled (i.e. minimized) so as to limit potential precipitation contact and leachate production, vector attraction, and daily cover requirements.

At the end of each work day, a layer of daily cover (typically 150 mm thick) will be installed over exposed waste. Reclaimed “soil” from lagoon remediation activities could also potentially be used as daily cover. Typically, a 5-day (minimum) supply of daily cover soil (if used) will be staged adjacent to the active working area. It is noted that alternative daily cover materials such as re-usable tarps may also be utilized based on availability to conserve airspace and minimize soil borrow requirements.

10.3 Nuisance Management

Potential nuisance sources consist of dust, odors, vectors and adverse weather conditions. These are typically controlled through the normal disposal procedures described above, and summarized as follows:

- Minimization of the size of the daily working face

- Application of daily cover soil or an approved alternative daily cover material such as re-usable tarps at the end of each work day

- Installation of the proposed final ET cover system and monofill gas components in phases as maximum waste elevations are achieved

Further measures may include application of commercial odor masking/neutralizing chemicals from misting stations as an alternative solution to odor problems. Adverse weather conditions (i.e. precipitation) will be mitigated through the installation of the runon/runoff stormwater management systems.

10.4 Inspections and Maintenance

Routine inspections will be carried out within the active, closure, and post-closure periods. Inspections and maintenance/repairs will be recorded on standardized forms and will be maintained on-site by site management personnel.

- During construction of the infrastructure, cell construction, and liner system installation, qualified Quality Assurance (QA) staff will be employed to assure that all features are installed in accordance with their intended form and function in substantial conformance to the project specifications.

- Construction and operations vehicles will generally be inspected prior to startup each day. Manufacturer’s recommended maintenance intervals will be followed in order to maximize vehicle dependability and to maintain warranty conditions.

- At a minimum, site security and access features (signage, fencing, gates, locks, condition of access roads) will be inspected on a monthly basis.

- Integrity of the final ET cover system (evidence of erosion, rodent/vector damage, etc.) will be inspected on a monthly basis and after major precipitation events.

- Erosion and sedimentation controls and stormwater conveyances (drainage ditches, culverts, and storm water collection lagoons) will be inspected on a monthly basis and after major precipitation events. Inspection will focus on evidence of cracking, clogging, settlement, sediment deposits, nuisance vegetation, rutting and washouts, holes and tears in liners, etc.

- Groundwater monitoring wells (if applicable) will be inspected and maintained (well, casing, lock, base will be inspected for signs of tampering) during quarterly sampling events by the groundwater technician.

- Landfill gas wells will be inspected and maintained during monthly tuning events by the gas technician, with well casing, wellhead assembly, valves, flexible hose inspected for signs of tampering or excessive deflection.

- Components of the leachate sump and pump systems will be inspected on a routine basis during acquisition of leachate flow data. The leachate technician will visually inspect all leachate piping, valves, meters, hoses, and connections for signs of leakage, damage or excessive wear. The leachate aeration lagoon will also be inspected focusing on holes and tears in the liner system.

- Gas movers (blowers), power generation equipment, and flare(s) will be inspected on a quarterly basis by qualified personnel.

10.5 Consumables

Consumables will be stored on-site at designated locations in sufficient quantities to provide efficient, safe and uninterrupted daily landfill operations. These will include:

- ***Vehicle fuels and maintenance supplies -*** Diesel, gasoline, air filters, oil filters, lubricants, belts, and other manufacturers' recommended spare parts.

- ***Personal Protective Equipment -*** Safety goggles, hard hats, gloves, visibility/safety vests, ear plugs, etc.

- ***Personnel Convenience Items -*** Bottled water, toilet tissue, hand soap, etc.

- ***Office Supplies -*** Printer paper and ink/toner cartridges, cleanup supplies.

Onsite disposal of municipal or municipal-like waste will be permitted. Arrangements for off-site disposal of waste oil, degreasers, etc. from equipment maintenance will also be required.

10.6 Minimum Staffing

Suggested minimum staffing is indicated below. Ultimate staffing requirements (the number of employees, working hours, expanded or limited responsibilities, etc.) will be further developed and finalized prior to initial construction. Staffing levels may increase or decrease depending on such variables as anticipated construction schedules, available skilled/unskilled labor pool, wage rates, and disposal rate capacities. Qualifications, skills, competencies and training requirements for each staff type should be clearly defined. The actual required staff will also depend on the number of working shifts and working hours.

- ***Management Team***
  Full-time site management team with administrative support staff responsible for oversight of other site personnel, training, disposal cell construction and closure/gas management implementation, contractor and engineering/CQA interface, overall daily site operations, records and reporting.

- ***Safety and Compliance***
  Full-time safety and compliance manager with administrative support staff responsible for safety, compliance, and associated reporting.

- ***Weighmaster***
  Full-time scale facility operator during open hours.

- ***Equipment Operators***
  Full-time heavy equipment operators to operate bulldozer(s), waste compactor(s), dump truck(s), wheeled loader(s), etc.

- ***Technicians***
  Full-time biogas/leachate technician(s).

- ***Mechanic***
  Full-time vehicle/engine mechanic.

- ***Laborers***
  Full-time manual laborers for waste vehicle spotting, housekeeping, litter pickup, grounds keeping, site cleanup, etc.

- ***Security***
  Part-time security to patrol facility boundary during off-hours.

11.0 CONCLUSIONS AND RECOMMENDATIONS

Development of the Ekeder Facility as a more efficient and environmentally protective waste disposal facility is being proposed within this Master Plan. Review of the existing facility and its current operational practices clearly indicate that remediation, reconfiguration, updated operational practices and commitment from a responsible management team are required for sustained long-term operations and environmental conservation. The major components that require planning, design and timed implementation are as follows:

- **Existing landfill disposal cells are unlined**
  Unlined MSW disposal cells allow downwards migration of leachate into the subsurface soils and regional groundwater and potential lateral migration into surface water resources. Portions of the existing landfill that will be overlain with waste will be lined with a geosynthetic slope cap liner. Proposed expansion cells will be lined with a geosynthetic base liner system with integrated leachate collection components.

- **Existing landfill exterior slopes are too steep**
  The existing slope areas will be filled and/or re-graded to provide a finished slope no steeper than 3H:1V. This slope is reasonable for subsequent placement of slope cap liner for future waste overlay and for the installation of the proposed final ET cover system. As of 1 November 2014, it is estimated that approximately 650,699 cubic meters of airspace is available in these slope fill areas and a conceptual approximate 3.72 meter thick lift can be placed over the entire plateau area. This will extend existing landfill life to the end of Year 1 (2015) as Cell 1/1A is constructed.

- **Existing compaction practices are inefficient**
  The lack of heavy compaction equipment and direct, focused coordination of the working face activities results in inefficient and rapid use of available airspace. Conventional landfill heavy compaction equipment is proposed to extend facility life.

- **Existing landfill capacity is limited**
  Lined expansion Cells 1 through 6 are proposed as well as slope cap liner over the existing landfill plateau and existing interior slopes to allow for an additional 10,479,390 cubic meters of landfill capacity for waste and daily cover soils.

- **Existing daily cover application is sporadic and/or incomplete**
  The lack of consistent/uniform daily cover exacerbates leachate production, traffic-ability, fugitive odors and emissions, negative visual impacts, and vector breeding. Daily cover operations are proposed to limit stormwater infiltration and associated leachate production, to limit odors, and to eliminate vector breeding.

  It is noted that all capacity and life expectancy calculations contained herein assume that soil daily cover accounts for 10% of the total landfill capacity. For the Ekeder facility, this equates to approximately 1,113,000 m^3 of daily cover soils. Use of alternative re-usable materials such as geosynthetic tarps would result in the use of less soil and would result in a corresponding increase in available airspace for waste disposal.

- **Existing landfilling does not include a closure cap**
  An evapotranspiration (ET) cover system is proposed over the existing landfill and proposed expansion landfill footprint to limit stormwater infiltration and associated leachate production, to limit odors, and to allow for more efficient landfill gas collection.

- **Existing resource recovery methods are unsafe and inefficient**
  A Materials Recovery Facility (MRF) is proposed.

- **Landfill gas is not adequately managed**
  The final design of the facility will include phased installation of landfill gas collection wells and transfer piping to a gas management facility in the site infrastructure area. The gas management facility may be configured for potential re-use of gas as electrical energy and for destruction with a backup flare station.

- **Stormwater is not effectively managed or segregated from contact with solid and liquid wastes**
  Stormwater drainage ditches and sedimentation/evaporation lagoons will be incorporated into the final design.

- **Zibar lagoons create nuisance odors at the site entrance**
  The scale house will be relocated further to the west and the site office facility will be relocated to the southeast corner of the facility.

- **Most of the existing liquid waste and Zibar lagoons are unlined**
  Remediation activities are currently underway and will continue for cleaning and lining of existing Zibar lagoons and permitting and construction of new Zibar lagoons

- **Waste disposal records are not maintained on-site**
  Records for waste intake, daily disposal operations, monitoring, inspections and maintenance will be maintained on site on standardized forms.

Timing for the remediation and or closure of the existing facilities (liquid waste lagoons) and for construction of new lined expansion cells (Cells 1 through 6) is linked to the projected waste intake rates, availability of soil, final filling of the existing landfill (3H:1V maximum exterior slope build out, development of the existing landfill plateau to facilitate positive drainage towards proposed lined cells), and achievable compaction.

12.0 REFERENCES

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